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AUTHOR Loughran, John; Derry, Nick
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ABSTRACT

This study was designed to explore students perceptions of how a change in pedagogy influenced learning. The study was undertaken as part of a professional development residency in which a teacher educator worked with the staff of a high school science faculty in an on-site professional development program focusing on classroom teaching and learning. The purpose of the research was to determine how students responded to changes in teaching approaches and learning strategies. The class involved in the study, taught by an inservice teacher with the teacher educator as an observer, was constructed to be more learning centered, encouraging students to better understand, articulate, and retain the course content. One particular strategy, student log books, is discussed. Data were collected through a survey and interviews, following an 8-week unit on electricity. The findings indicated that the students enjoyed the way teaching was conducted. However, although they understood what was happening and why, and although they recognized the changes in their approach to learning, in general they found it difficult to accept that such changes should become the norm. The data suggest that this dilemma was related to the effort necessary to learn in a more active and meaningful way which requires more experience and time than might initially be expected. Even though students might recognize the value of learning for understanding, that alone is apparently not sufficient to encourage them to adopt it as "normal" practice. Four appendices include: the student survey form, the interview protocol, interview codes, and reports on codes. (Contains 17 references.) (ND)

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Researching teaching for understanding: the students' perspective

John Loughran & Nick Derry.

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Researching teaching for understanding: the students' perspective.

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Introduction

> Teacher: "No matter how well I think I teach a topic, the students only seem to learn what they need to pass the test, then, after the test, they forget it all anyway."

It is not uncommon to hear teachers talk in this way. Despite the teacher's good intentions, students do not always accept the opportunities for learning placed before them. An insight into this type of dilemma was unexpectedly made possible as the result of a collaborative approach to teaching and learning between a Teacher Educator and the staff of a High School's science faculty. In this case, a professional development program focussing on classroom teaching and learning at the school site had been initiated by the Science Faculty of the school. The Teacher Educator was expected to work in the school with the teachers so that professional development was a normal part of the workplace rather than as something that occurred in another place at another time. Through the professional-development-in-residence approach (Loughran, 1994) insights into students' views of learning were able to be explored because of the ongoing nature of the professional development as an on site collaborative venture.

Through this collaboration the second author's desire to teach for understanding caused him to reflect more and more on his teaching. Consequently, the planning, organisation and teaching of his science classes revolved around his attempts to encourage his students to become more metacognitive in a manner similar to that described in the PEEL project

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(Baird & Mitchell, 1985; Baird & Northfield, 1992). This led to his teaching becoming more learning-centred as he employed teaching strategies designed to probe students' understanding. He introduced concept maps and POE's (Prediction-Observation-Explanation; see, for example, White and Gunstone, 1993) as strategies to help his students better articulate their understanding of the content under consideration. This also led to a development in teacher knowledge. Instead of making assumptions about students' learning, a more accurate picture of what the students did and did not understand was being developed and this influenced subsequent teaching episodes.

By the end of the first semester the second author's Year 9 science class had experienced a range of teaching strategies, were used to having an observer (first author) intermittently present in their classes, and appeared receptive to the change in teaching style they had been experiencing. The classroom teaching and learning experiences resembled a Children's Science approach to teaching (Driver, 1983; Driver et al., 1985; Gunstone 1990) as the value of understanding students' approaches to learning science concepts was influencing the teaching.

The first unit in the second semester was electricity and was a good opportunity to research how the students were really responding to the changes in the teaching approaches they were experiencing. The first author was an observer for many of the lessons during the unit and both authors met to both plan and review the lessons. However, the overall responsibility for the classroom teaching was always the domain of the teacher; the observer's main role was to act as a 'critical friend'. Throughout the unit, one major advantage derived through this 'critical friend' relationship was that ideas that might have influenced the direction of a

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lesson could be discussed *during* a lesson so that learning opportunities could more readily be acted upon. For example, during many of the laboratory sessions, as the students were conducting their experiments, we would move from group to group and talk with the students about their approach to the work. We would then briefly discuss what we had learnt about the students' understanding of the experiment and use this to reshape the teaching. A similar approach was common during other teaching episodes as well. We continually strived to communicate what we had learnt through observation and student interaction so that, through these brief encounters, the teaching approach could maintain an immediate responsiveness to our perceived view of the students' learning. Therefore, it was not uncommon for the teacher to alter his approach, adjust the pace of the lesson, reinforce particular aspects of the content or introduce something new during the lesson as a result of these brief within class discussions.

During this unit of work, one particular learning strategy introduced to the students was the use of log books (Derry & Loughran, in press). Students were expected to record in the logbook all of their observations, document their results, write their questions, develop their hypotheses and conclusions, and generally develop their understanding of the unit; the log book was to be their notes about their learning and as a document to show how they 'came to know'. It is important to stress that the purpose of the logbook was not a superficial replacement of teacher generated worksheets with student generated worksheets. The logbooks were to be used to record the students' perceptions of the teaching and learning episodes as well as the questions raised in their minds during the investigations. Students were encouraged to record at the end of each entry what they had learnt that lesson, and what still puzzled them. As well as this, the logbook was to be used

to document and describe in their own words new or unfamiliar terms in the form of a glossary.

The log books were designed to encourage the students to develop their understanding of electricity as they worked through a number of puzzling situations presented through a series of probes; initially taken from the work of Osborne and Freyburg (1985). Through this approach it was hoped that the students would see the need to better understand electricity as many of their misconceptions could be challenged in ways that would not occur in a more 'traditional' classroom setting where the correct scientific explanations tend to be given to students; unfortunately research shows that this has little impact on students' understanding as this scientific knowledge has little influence on their explanations of electricity in the 'real world'.

The students' logbooks were collected at the end of each lesson then distributed again at the start of the following lesson. The aim of this rather time consuming process was to encourage the students to document and think about their work during the lessons rather than write up their ideas at a time distant from the experience. In writing up their thoughts, students had the opportunity to discuss investigations in small groups both with and without the teacher. There was also a whole class debriefing in which all students had the opportunity to share their results and ideas. It was anticipated that this would encourage the students to think more carefully about what they were doing during a lesson as they were largely responsible for constructing their own notes. Also, knowing that their questions might be used to direct the learning in the next session, it was hoped that this would encourage free and honest questioning of concepts, and shed light on misunderstandings, in ways that were less likely during 'normal' classroom interaction.

The logbook entries were so interesting and revealing that the original notion of perusing eight or so after each class soon grew to reading all of them. It was also apparent that through the logbooks students were able to safely raise their concerns about not understanding the work. This was particularly important for those students who felt uncomfortable about verbalising their understanding in class debriefings.

Gathering students' views

The teaching/learning approach in the electricity unit was based on the probes designed by Osborne and Freyburg (1985) with many of the lessons being structured in response to the students' 'need to know' (Derry and Loughran, 1994). At the end of the unit (8 weeks) the students (N=28) completed a questionnaire (Appendix 1) designed to determine their perceptions of the experience. In addition to this the students were also individually interviewed (see Appendix 2 for the interview protocol; during this lesson 2 students were absent therefore n=26). The interviews offered a qualitative data source to enhance the understanding of the quantitative data obtained from the questionnaire. All of the interviews were performed by a research assistant who was previously unknown to the students. This was intended to minimise the possibility of the students saying what they thought their teacher might wish to hear, and to reinforce the idea that their (anonymous) views had no bearing on their assessment or their teacher's opinion of them.

Students completed the questionnaires in the latter stages of their final lesson during the electricity unit and their responses were collated and analysed that evening.

Interviews were conducted in science lessons immediately after the students had completed the electricity unit. Interviews were of approximately 10 minutes duration and were audio taped (with students' permission) then later transcribed. The transcriptions of the interviews were then coded (for codes see Appendix 3) using the qualitative data analysis software program NUDIST[1]. One of the advantages of using the NUDIST program is that it creates reports for all of the coding that is used in analysing data so that overviews of trends are able to be determined after initial coding has been completed. Appendix 4 demonstrates the reports for the major codes used in this study.

Some of the conclusions drawn from the students' responses to the questionnaire were used as a starting point for discussion in the interviews in an attempt to develop a better understanding of the reasons for the general trends that seemed apparent from the questionnaire data. In essence, we were attempting to test both the conclusions we had drawn as a result of the questionnaire (and our classroom observations) and to gain some richer insights into some of the reasons for the seemingly contradictory responses (as will be demonstrated in the next section) from the questionnaires.

[1](Non-numerical Unstructured Data Indexing Searching and Theorising copyright Replee Pty. Ltd. Qualitative Solutions and Research P/L and La Trobe University, Bundoora, Victoria, Australia) is a qualitative data analysis program which enables the user to sort and recall coded segments of data. Therefore, responses to particular issues or questions from different individuals may be more readily summarised, reviewed and compared to determine trends within specified areas. Areas of study can be general or specific and is determined by the initial coding. The number of codes is not limited nor is the number of sub-codes which may be nested within one another.

Students' views

Table 1 is a summary of the students' responses to the questionnaire. The table has been constructed so that the first data line for each question demonstrates the individual responses for each of the 5 categories of the Likert Scale while the second line is the sum of the two responses at either end of the scale; ie. the Strongly Agree and Agree have been added together and the Disagree and Strongly Disagree have been tallied. The purpose of this approach is to demonstrate both the specific and the general trends for each question in a way that may be quickly and easily understood by the reader.

The questionnaire data raises a number of issues about the way the students perceived the teaching and learning during this unit of work. Although just over half the students found the unit to be interesting, there was still almost one third of the class who did not. Interest in the unit, it would seem reasonable to suggest, would be related to the teaching style, yet question 9 shows that almost 80% of the class liked the way the unit was taught; so strong is this response that in fact none of the students disliked the way teaching was conducted. Strangely though, question 4 shows that the students were relatively evenly divided in their opinion about having the unit taught in the same way if they were to do it again. Approximately one third would not like to be taught in a similar fashion again, one third were unsure and one third would have been satisfied with the same approach. The apparent contradiction in these results raises the question, if there was not major disinterest in the unit and if they liked the way the unit was taught, why was there not a much more positive response to having the unit taught in the same way again? This is further compounded by the students' response to question 15. There is overwhelming agreement (75%) that as a

result of the way the unit was taught that the students found themselves thinking more than they considered they normally would about the work they were doing. Only 11% of the students disagreed with this statement and no students strongly disagreed with it. The question recurs, why would they not want to be taught the same way again?

The difficulty of interpreting the data may well be an indication of how complex teaching and learning are and how difficult it is to untangle this complexity by simply taking 'snapshots' through such things as questionnaires. It may also reflect a growing understanding of this complexity by the students themselves. For example, question 5 shows that over 80% of the students believed that they understood electricity better as a result of completing the unit; no students disagreed with this statement. However, again, the cohort was relatively equally divided in their view of the difficulty involved in understanding the work. One third felt that the unit was easy to understand, another third were unsure and the remaining third did not think that electricity was easy to understand. It is reasonable to suggest that although the students felt their understanding was enhanced by completing the unit, that they also began to recognise that "knowing" and "understanding" were not necessarily synonymous; as their understanding developed they may have started to better recognise the complexities of the concepts under consideration and how difficult it is to master the content.

This proposition is supported by the responses to question 2. Less than 4% of students believed they had not worked hard to question and find answers about the things that puzzled them during the unit. Almost 70% believed that they worked at resolving the challenging/puzzling situations that arose during their studies. This also clearly suggests that the students were positively engaged in their studies.

Table 1 Questionnaire results (expressed as a percentage).
1 = Strongly Agree; 2 = Agree; 3 = Unsure; 4 = Disagree; 5 = Strongly Disagree
* (N=27; one question not marked by a student)

1.	(1 + 2)	2.	3. Unsure	4.	(4 + 5)	5.
1. I thought the unit on electricity was interesting.						
3.6		50	17.9	21.4		7.1
	53.6				28.5	
2. I worked hard to question and find answers about things that puzzled me during the unit on electricity.						
3.6		64.2	28.6	3.6		
	67.9				3.6	
3. I thought the unit on electricity was easy to understand.						
3.6		28.6	35.7	25		7.1
	32.2				32.1	
4. If I did this unit again I would like it taught the same way.						
7.1		28.6	32.2	21.4		10.7
	35.7				32.1	
5. I understood electricity better after than I did before the unit.						
46.4		35.7	17.9			
	82.1					
*6. I prefer science lessons when the teacher tells me what I have to know.						
17.9		50	21.4	7.1		
	67.9				7.1	
7. I think log books were a good way of helping me to learn.						
25		39.3	10.7	17.9		7.1
	64.3				25	
8. I would like to use log books in science all of the time.						
14.3		10.7	17.9	42.8		14.3
	25				57.1	
9. I liked the way the electricity unit was taught.						
42.9		35.7	21.4			
	78.6					
10. *The test on electricity was the same as the work we did in class.						
7.1		39.4	21.4	21.4		7.1
	46.4				28.5	
11. *I often ask questions in class when I am unsure of the work.						
7.1		42.8	28.6	17.9		
	50				17.9	
12. *I asked more questions in electricity unit than I normally do.						
3.6		25	35.7	25		7.1
	28.6				32.1	
13. *I prefer science lessons when the teacher lets me work things out by myself.						
3.6		21.4	35.8	21.4		14.3
	25				35.7	
14. *Science is taught in the same way as all of my other subjects.						
10.7		17.9	57.1	10.7		
	28.6				10.7	
15. Because of the way the electricity unit was taught, I found myself thinking more about the work than is normal for me.						
46.4		28.6	14.3	10.7		
	75.1				10.7	

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The introduction of log books during the electricity unit was designed to enhance students' understanding of the content and to help them to accept (and develop) more responsibility for their own learning. The responses to question 7 illustrate that the use of logbooks may well have helped this to occur as 64% believed that the log books were a good way of helping them to learn. However, 57% did not want to use log books all of the time in science and only 25% thought that they might like to use them more often. Again, the results highlight a dilemma. It appears as though the students recognise the learning advantages available through the use of log books, yet they would prefer not to continue in this vein.

Questions 11 and 12 refer to the students' approach to questioning. 50% believed that they often asked questions in class when they were unsure of the work but only 28% felt that they asked more questions during the unit than they considered was normal. This could well be that the use of logbooks, the small group discussions and the divergent nature of the work changed the 'normal' questioning protocol and therefore influenced the students' view of questioning in this instance; but this is only supposition. Certainly during the unit it appeared from classroom observation that there was a high proportion of student initiated questioning.

As if these results are not confusing enough, consider the response to question 14. In a unit where the teacher was overtly developing a teaching approach to the content that was very different from the prescribed syllabus, 57% of students were unable to distinguish between this approach to teaching and that of their other subjects. Strangely, only 28% considered the teaching to be different.

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The difficulty in interpreting these results is strikingly apparent when one considers the response to question 13. Only 25% of students preferred science lessons in which they could work things out for themselves despite the fact that this unit of work was organised in such a way and that students stated that they enjoyed it and learnt as a result of that approach. Generally then, it would appear as though the students readily recognised some of the opportunities for learning that were being placed before them, but they preferred to assume less responsibility for learning than was expected during this unit of work.

The questionnaire data raises a number of issues about teaching and learning and students' understanding and perception of each. Fortunately, the interviews offered an opportunity to untangle some of the confusion created by the questionnaire data and allowed us to explore some of the conclusions further.

Interviews

During the interviews the students were asked about their perception of the way the unit was taught and how they thought that influenced their learning. Having completed approximately 10 years of formal schooling, these students were indeed experienced observers of teaching. In most cases they were able to discuss the teaching approach they had experienced during the electricity unit and its value to them as learners.

> S232: I thought it was pretty good. Well before I didn't know much about electricity so I learnt a fair bit...It was a bit different because we had more hands on activities. I thought that was better, better than just like the teacher standing out

[2]All students quoted in this paper have been assigned a number as a pseudonym derived simply from the number given to them during their interview.

> the front and talking to us...You found out things for yourself...I liked that.

A major advantage of interviewing was that it offered an opportunity to probe students' views in more depth than was possible through the questionnaire. From the interviews, 96% (see "node reports" Appendix 4) of the students had a positive view of the teaching they had experienced during the electricity unit and much of this satisfaction was related to their sense of "discovery" through the teaching and learning. However, they also recognised what they perceived as limitations with this approach.

> S17: I thought it [teaching] was pretty good, made us think for ourselves and stuff. I wouldn't like that method all the time [though], because it just gets a bit boring, [pause] or hard.
>
> I: It gets boring or hard?
>
> S17: Yeah, if you did it all the time the same sort of system. I mean, it was good because we got to think for ourselves but I don't know, just, if we did it all the time I'd find it hard to always do it, for like every unit...and if it's hard, in a way, you turn off...I suppose if the unit interests you then you'll try to find out stuff for yourself, like that's what they tried to do in this unit, but if you find it a bit boring then I suppose you just switch off, so if you start the actual unit [and] you find it boring well..[however] when he writes stuff on the [chalk]board then you can still learn it even if it's a bit boring.

This quote is indicative of the majority of students' responses. There is an obvious recognition of the pleasing aspects of enhanced interest in the content being studied and the opportunity to explore and discover learning for oneself, but for many there is also another aspect to be considered beyond these positive attributes. They believed that accepting more responsibility for learning required a greater effort (or commitment) and that a lack of motivation or interest could have important consequences for learning, consequences that could be compensated for if the information was more readily available in other forms (for example if it was supplied on the chalkboard). Attempting to weigh up the advantages and disadvantages to

learning in this manner may be why there was an inconsistency in the questionnaire data. The students enjoyed the way the unit was taught but were not sure that they would want to be taught in a similar way in future. In fact, when this inconsistency was broached during the interviews, many students offered explanations to account for their peers' difficulty with this:

> S24: I think some people just didn't like having to sit down each lesson and write up what they'd done, cause it was, sort of the onus is on you to write what you'd done and if you didn't bother writing that well you would have suffered in the test and done very badly. But if you'd kept the log up to date I couldn't see any problems.
>
> I: So you're suggesting are you, that they didn't like it, would prefer another method, because too much was left to them?
>
> S24: Yeah, yeah, you weren't spoon fed the information too much. You had to work it out yourself.
>
> I: You seem to be the sort of student that likes finding out things for yourself.
>
> S24: Yeah, I like that in a subject.

As an aside to this, it was interesting to note that although some students could account for this discrepancy in the results of the questionnaire data, only 5 students actually accounted for this inconsistency from their own perspective:

> S6: I liked doing this unit, I liked working things out for myself because you get to understand it really well but I also like being told how to do things so I know it's right and I understand it and I take it in a bit more...I like doing activities and working them out but I find it easier to understand when I've been told what to do and I understand more clearly [what to do].

This highlights the learning tension which seems to underpin the difficulty the students had during this unit of work. They enjoyed the activities, were motivated and interested in the work, and appeared to recognise that their understanding of the content was enhanced through the teaching, yet they

still had a strong sense of wanting to "know by being told". Some spoke of feelings of frustration associated with a more student-centred approach to learning, but the majority were more concerned with the amount of time and effort involved; much of which they thought could have been avoided if they had "been told what to learn".

> S21: I found it [teaching] was useful but I think it would help and we would learn a fair bit more if we were told some of the answers rather than [the way] we had to work out all of the answers for ourselves. We'd find out a lot more things if we were told a few answers...we eventually got it but it took ages. Like it would be easier if we were told the answer and then we'd work out how to get it...we had to spend a lot of time trying to find the right answer...
>
> I: You don't feel that in finding the right answer your learning was a bit...
>
> S21: ...Oh, we learn but it's at a slower rate because we had to trial it, trial and error, find out the answers.
>
> I: The material that you learnt using that method, did that stay with you?
>
> S21: Um mostly yeah.
>
> I: Did you feel during the unit that the teacher was getting you to discover things for yourself?
>
> S21: Yeah, that was good that was fine it was just that some of the answers, it would help if we were told [more] and then we could work out [the rest]. We'd get a bit more done if we were told some of the answers. Like we had to work out absolutely everything.

It is difficult to be sure, but it may be reasonable to suggest that the students do not readily differentiate between the organisational aspects of learning (what to do or how to go about an experiment or activity) and attaining a better understanding of a concept. If there is no differentiation between these two aspects of learning, as seems to be the case in many of the quotations above, their frustration with getting organised and the time involved in doing an exercise may lead to some confusion in their

understanding of the nature of their learning for a particular concept and the subsequent strength of conviction to that understanding.

Understanding learning

As the previous section suggests, the students did not have a specific vocabulary to describe their approach to learning, but nonetheless, they were still more than capable of conveying their understanding of what they were experiencing. It appeared that as they talked about their learning preferences (and this may well have been the first time they had ever discussed the topic) that they began to recognise the dilemma more themselves. As they spoke about the way they preferred to learn and compared that to the commitment needed to continually work in that way, they similarly recognised the teacher's purpose for approaching the unit the way he had.

> S8: ...if you're just taught a certain thing that's all you know, if you are allowed to experiment and you learn different things that maybe someone else doesn't know and then everybody else learns something new then that's better for you [pause] so I don't think we should be taught in that way [by being told] all the time [pause] it's probably easier to just sit back and listen rather than to get up and do all these experiments and things like that...I think there is a degree, you need a degree of self searching, I think.
>
> Interviewer: Well what was the idea of using a log book?
>
> S8: Basically so we could write down what we learnt. And so we could refer back to it, cause I think Dr. Derry said we could use them in our tests. Also I suppose for him to gain information to see whether we were capable of writing them down, yeah, for him as well to see what kind of students we are. I think you need something to refer back to, otherwise, you might just forget...you always take things in but there are things you certainly might forget so...
>
> I: But you can refer back to notes?
>
> S8: ...if you're given a handout you're generally just pursuing the more short answer questions, and I don't think it's as detailed, so where as if, well my log book anyway was more detailed and I set out exactly what I did. I mean, it wasn't a

stress, he gave us time to write everything down so it was quite enjoyable really.

The log books then appeared to be a catalyst for thinking about learning. As they were incorporated into the teaching program and consistently perused by the teacher, it was difficult for students to ignore them. Moreso, as the students' questions, hypotheses and conclusions from the logbooks were also used as class problems or discussion points, their use was constantly being reinforced such that their value as a tool for learning was well recognised by the students.

S23: It [logbook] was sort of like to get you to be responsible, to get everything that you needed.

***

S3: It [logbook] was a, well first I didn't really like it because you had to write out everything but then you learn more by writing it than just reading it, having notes given to you, you learn more by writing it yourself...so you could learn more, I think you learnt more by writing it yourself.

***

S20: Yeah. I thought the log was really good. Much better than the other systems we've had. I thought it was very good like you had to really think about what you were doing to write it down back in your logs, so you really had to understand what you were doing so you could write it down and make it clear to yourself what you actually had done in that class or period or whatever.

***

S24: Um I thought it was quite good. It was, I understood it quite well, the method he did, he gave us certain notes in class but we had a log we had to keep and he would give us certain notes on that but a lot of the stuff we had to learn for ourself. We'd do experiments, or practical things, and then we'd have to write them up in our log book. And although he didn't have any say over what went in our log book specifically you had to keep it up to date and certain things had to be put in

There is little doubt then that the students understood the purpose of the log books as a tool to aid their learning and 77% (see Appendix 4) had a positive view of their use. This then helps to clarify an important aspect of the apparent confusion from the questionnaire data. Although the students do not have a specific language of learning, and even though they may not

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fully differentiate between the organisational and cognitive aspects of their learning, they are well aware of the learning approach hoped for as a result of the teaching adopted in the unit. They also acknowledge the difference between actively developing their own understanding of content as opposed to memorising or passively adopting the 'prescribed view'. This is particularly noticeable in their responses to the approach to assessment adopted at the end of the unit.

The end of unit test was designed to reflect the approach to the teaching and learning the students had experienced. Therefore, the test involved practical activities (making circuits) and other problem solving activities similar to those completed in class. The test was also an 'open-logbook test' so that students could refer to their 'own' notes about different problems as required. It was anticipated that students who had used their logbooks appropriately during the unit would not have a great reliance on them during the test as their understanding would have been enhanced by better processing as they were learning. Therefore, although they would be able to use them as a reference during the test, their real value would have already been realised.

The students also recognised this, yet despite being aware of their access to the logbooks for the test throughout the unit, there was a marked difference between 'knowing' and 'doing' when it came to the test. In many ways it appears as though the test was as much a measure of the students ability to adapt to a change in the 'script' (White, 1989) of learning and assessment as it was a test of their understanding of the unit of work.

I: The questions in the test paper. Did any of those surprise you?

S5: Um, well I, yeah, they did a bit. Like I got a bit confused and especially because we had our log books with us and I found

it was pretty hard to complete in the time given. And I sort of rushed them a little bit. When we had to set up a circuit, ourself, like it was OK setting up the actual circuit but when we had to do things with it, like mine didn't really work. I don't know, I probably did it wrong but I didn't know how to do it.

I: You seem to suggest having a log book made it more difficult.

S5: Well it was good in a way but I don't know, it was just so different, like we haven't had it before, so I suppose it's sort of a change. But I thought it was good but it was a bit confusing at first.

•••

I: The questions in the test paper. Did any of those surprise you?

S11: Pretty tricky.

I: The questions were tricky?

S11: Yeah. Like you just had to go and think about them. Like even though you had them in your logs you had to try and like think about it further. You know because not all your information I don't think was in our logs but that's probably up to the person when they're making up their logbook.

•••

I: Did any questions on the test surprise you?

S17: No not surprise me, just I didn't know some of them that's all.

I: Why didn't you know them?

S17: I hadn't written enough in my log book.

I: Hadn't studied enough?

S17: Yeah, well I hadn't written out what I was doing and that, you know, actually as I went a long in the log book.

I: I see you missed out bits.

S17: Yeah, missed bits and then didn't write them clearly enough.

I: How did you miss out on them?

S17: I don't know, wasn't paying attention or I just wrote it without thinking.

I: Just didn't appreciate the significance or the importance of something is that it? Didn't write it down.

S17: Yeah, or I didn't, sort of, some of the things we were supposed to write our own conclusions and sometimes I didn't write down a good clear kind of conclusion.

The students' responses to the test (and its accompanying open-access to logbooks) sheds more light on the confusion in the students' minds about their views of the teaching and learning they experienced. After the event (test) it became strikingly obvious to many (as the quotes above illustrate) how their use of the logbooks and their subsequent learning were being challenged by the form of assessment adopted. It would appear as though student learning is challenged not only by the intent of changes in approach but by the nature of change itself (regardless of expected outcomes). For the students to come to grips with the changes, then to adjust their learning behaviours accordingly, appears to be more time dependent than we initially expected. It could well be that if these students experienced a similar approach to teaching and learning again, that they might better 'believe' the benefits and value of accepting more responsibility and control over their own learning. In this case, for the students to develop the skills to deal with the changes introduced involved aspects of learning that were inconspicuous at the time.

Overview

There is little doubt that the students enjoyed the way the teaching was conducted. It maintained their interest, sparked their curiosity and gave them more freedom to learn and discover for themselves. The structural features of the lessons that allowed this to be the case as well as the introduction of the logbooks were readily noted by the students and were viewed positively by them.

> S9: Well I think, it's good to do like experiments instead of always writing off the board because you can find out why things are happening and to work in smaller groups with the teacher is good, instead of just together.

However, although they understood what was happening and why, and although they recognised the changes in their approach to learning, they (generally) found it difficult to accept that such changes should become the 'norm'. There are clear messages in the data which suggest that this dilemma is related to the effort necessary to learn in a more active and meaningful way, and also that 'believing' in the value of this approach requires more experience and time than might initially be expected.

Gardner (1991) suggests that there are three types of learners, the intuitive learner, the traditional student and the disciplinary expert. The traditional student is "the youngster from age seven to age twenty, roughly, who seeks to master the literacies, concepts, and disciplinary forms of the school [and unlike the disciplinary expert] their knowledge is limited to the usual text-and-test-setting, and they are [not] eligible to enter the ranks of those who "really" understand." (p.7) It may well be that the large majority of the students in this cohort have been well trained as traditional students. The need to develop a deep understanding of a subject is not viewed as particularly important because progression through the schooling system can be achieved without it; and in this case appears to have been very well reinforced by Year 9.

This is not to suggest that the students are poor learners, more so, that in this case they have learnt how to learn sufficiently well to succeed in school without expending excessive time or effort. Therefore, it is possible that they have developed metacognitive skills that allow them to take a line of 'least resistance' to learning by addressing their work with a question such as, "How much of the work do I need to understand to satisfy the requirements of this class?" and this would be reinforced by teaching that

did not encourage individuals' to accept responsibility for their own learning. So it may be that through this unit of work, the students began to struggle with the personal considerations of intelligibility, plausibility and fruitfulness (Hewson, 1981; 1982; Posner, Strike, Hewson & Gertzog, 1982) with respect to their conceptions of learning. They recognised that the approach to learning being advocated was intelligible (ie. it made sense and was able to be understood), and that personally applying it was plausible (ie. it appeared a reasonable thing to do). However, they may have been struggling to accept that it was worth the effort, (ie. that it could be fruitful).

This difficulty with the fruitfulness of learning for understanding could be because their normal practice (knowing without a deep understanding) is not perceived as being less rewarding than the fruitfulness of the approach they were being challenged to adopt through the teaching. Hence, until the end of unit test, the rewards associated with greater understanding may have been limited to those who recognised and valued the implicit rewards from their efforts. The recognition of the value of learning for understanding may have been more explicitly demonstrated through the approach to assessment but as the test was their last organised learning experience in the unit, this realisation did not help them with the task at that time. Therefore, the external value which may have prompted them to better recognise the fruitfulness was too late to impact on their practice.

The confusion highlighted by this research may then be a snapshot of the exploration of students' thinking about the fruitfulness associated with learning for understanding compared to the effort associated with so doing, and the rewards (or lack of thereof) schooling offers for learning for understanding.

S5: Well, I thought it was taught quite well, but it was a bit, I don't know, I found myself being a bit confused with it all.

I: Can you say why you were confused?

S5: Well, it was sort of because the log books were different and we had to work out answers for ourself too, and so those sort of 2 different things in one unit. And um, but it was taught well.

I: You liked it?

S5: Yeah.

I: And you'd choose to work in that method in future would you?

S5: Yeah, yeah, [pause] I'm not sure.

The notion of fruitfulness and its application in learning science has been well documented in research associated with conceptual change. As Hewson (1981) and Posner et al (1982) have demonstrated, being dissatisfied with an existing conception is not sufficient for a person to abandon the conception in favour of a new conception. In this case, I would argue that the same applies with these students in relation to their conception of learning. Although they appear to recognise the limitations of their existing conception of learning (relying on the teacher for the "correct" information as a sign post of what to learn), a more student-centred/responsible approach (as a result of a change in the teaching approach and the teacher's expectations of students' learning) and the enhanced understanding accompanying it, is in itself not sufficient to cause them to abandon their existing conception of learning. This may be because the fruitfulness of the change is not immediately obvious or rewarded.

> Fruitfulness is complex and hard to achieve. One useful way to consider the idea is in terms of...external fruitfulness resulting from factors external to the student, such as the nature of the assessment the student will undertake...[or internal fruitfulness] such as considering whether or not a new idea gives a more powerful explanatory system to apply to the world. Of these two, clearly, internal fruitfulness is far more likely to promote conceptual exchange but far harder to achieve. Its achievement is closely intertwined with students understanding

> and controlling their own learning. (Gunstone, et al., 1992, p.176)

It could well be then that if these students experienced greater external rewards for approaching learning in a more responsible and meaningful way that this could encourage the acceptance of such an approach so that internal fruitfulness could more readily occur and influence a change in understanding of their conception of learning.

Conclusion

This study was designed to explore students' perceptions of how a change in pedagogy influenced learning. What initially appeared an interesting and useful approach to understanding and evaluating the changes has highlighted the difficulties of unravelling the complexities of the relationships between teaching and learning. The web of confusion and intrigue uncovered through the data sources has been difficult to unravel as the apparent contradictions have been explored.

It seems clear that even though students might recognise the value of learning for understanding, that alone is not sufficient to encourage them to adopt it as 'normal' practice. The time and effort associated with being actively engaged in learning may not be sufficiently rewarded in schools, not least because it is equally time and energy consuming for teachers to create such an environment, so that although we may know much about how to make students more able as learners, this does not mean that they will become more able learners. There is much more to being able than knowing how to be able. Like Gunstone (1991), we too believe that, "We have learned much in recent years about how to help students be able; sadly, we are a long way from understanding what might make a student willing." (p.77)

In an era of ever increasing expectations of schooling, greater retention rates and calls for greater teacher accountability, the challenge for educators who genuinely desire to make learning more meaningful and useful for students is how to help students become more 'willing to be able'.

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Appendix 1

Year 9 Electricity Unit.

The following survey has no bearing on your assessment for science. It is designed to help your teachers better understand your ideas about teaching and learning. For each of the following statements, please circle the response you think best represents your ideas, then briefly explain why you feel that way.

1. I thought the unit on electricity was interesting.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

2. I worked hard to question and find answers about things that puzzled me during the unit on electricity.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

3. I thought the unit on electricity was easy to understand.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

4. If I did this unit again, I would like it taught the same way.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

5. I understood electricity better after the unit than I did before the unit.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

6. I prefer science lessons when the teacher tells me what I have to know.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

7. I think log books were a good way of helping me to learn.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

8. I would like to use log books in science all of the time.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

9. I liked the way the electricity unit was taught.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

10. The test on electricity was the same as the work we did in class.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

11. I often ask questions in class when I am unsure of the work.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

12. I asked more questions in the electricity unit than I normally do.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

13. I prefer science lessons when the teacher lets me work things out by myself.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

14. Science is taught in the same way as all of my other subjects.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:

15. Because of the way the electricity unit was taught, I found myself thinking more about the work than is normal for me.
Strongly Agree Agree Unsure Disagree Strongly Disagree
Why:
How would you prefer science classes to be conducted? Why?

Appendix 2

Interview protocol

1) How did you see the way the electricity unit was taught? Was it in any way different to other science units?

2) From the questionnaire, many students seemed to suggest that they liked the way the unit was taught but that they would prefer it to be taught in another way. Can you explain that?

3) Are you the type of student who normally asks/answers questions in class? Why/why not?

4) What did you think of the log book? Why do you think it was used? Did you like it/dislike it?

5) If you had a choice in how the unit was taught, what would you prefer?

6) How was the test? Did any of the questions surprise you?

7) What do you think would be a good way to learn about electricity?

8) What do you think is a good way to learn about electricity?

Appendix 3

Interview codes

NUD•IST Macintosh Version 3.0 GUI.
Licensee: John Loughran.

PROJECT: Students views, User John Loughran, 8:13 pm, Feb 8, 1995.

(1) /view of teaching
(1 1) /view of teaching/POSITIVE
(1 2) /view of teaching/NEGATIVE
(1 3) /view of teaching/TO QUESTIONNAIRE
(2) /Test Response
(3) /View of Learning
(4) /Questioning
(4 1) /Questioning/YES
(4 2) /Questioning/SOMETIMES
(4 3) /Questioning/NO
(5) /Log Book
(5 1) /Log Book/POSITIVE
(5 2) /Log Book/NEGATIVE
(6) /Preferred Teaching style
(6 1) /Preferred Teaching style/SURE
(6 2) /Preferred Teaching style/UNSURE

Appendix 4: Reports on codes.

(1 1) /view of teaching/POSITIVE
*** Documents indexed by this node are:
1: S1 2: S11 3: S12 4: S13
5: S14 6: S15 7: S16 8: S17
9: S18 10: S19 11: S2 12: S20
13: S21 14: S22 15: S23 16: S24
17: S25 18: S26 19: S3 20: S4
21: S5 22: S6 23: S7 24: S8
25: S9
*** This is 25 documents out of 26, = 96%
****

(1 2) /view of teaching/NEGATIVE
*** Documents indexed by this node are:
1: S10
*** This is 1 document out of 26, = 3.8%
****
****

(1 3) /view of teaching/TO QUESTIONNAIRE
*** Documents indexed by this node are:
1: S1 2: S11 3: S12 4: S13
5: S14 6: S15 7: S16 8: S17
9: S18 10: S19 11: S20 12: S21
13: S22 14: S23 15: S24 16: S25
17: S26 18: S3 19: S4 20: S5
21: S6 22: S7 23: S8
*** This is 23 documents out of 26, = 88%
****

(2) /Test Response
*** Documents indexed by this node are:
1: S1 2: S10 3: S11 4: S12
5: S13 6: S15 7: S17 8: S18
9: S19 10: S2 11: S20 12: S21
13: S22 14: S23 15: S24 16: S25
17: S26 18: S3 19: S4 20: S5
21: S6 22: S7 23: S8 24: S9
*** This is 24 documents out of 26, = 92%
****

(3) /View of Learning
*** Documents indexed by this node are:
1: S1 2: S10 3: S11 4: S12
5: S13 6: S14 7: S15 8: S16
9: S17 10: S18 11: S19 12: S2
13: S20 14: S22 15: S23 16: S24
17: S25 18: S26 19: S3 20: S4
21: S5 22: S6 23: S7 24: S8
25: S9
*** This is 25 documents out of 26, = 96%
****

(4 1) /Questioning/YES
*** Documents indexed by this node are:
1: S13 2: S14 3: S18 4: S20
5: S25 6: S3 7: S5 8: S7
9: S8
*** This is 9 documents out of 26, = 35%
****

(4 2) /Questioning/SOMETIMES

*** Documents indexed by this node are:
1: S15 2: S16 3: S17 4: S26
5: S6 6: S9
*** This is 6 documents out of 26, = 23%
****

(5 1) /Log Book/POSITIVE
*** Documents indexed by this node are:
1: S1 2: S11 3: S12 4: S16
5: S17 6: S18 7: S19 8: S2
9: S20 10: S21 11: S22 12: S23
13: S24 14: S25 15: S26 16: S4
17: S5 18: S6 19: S7 20: S8
*** This is 20 documents out of 26, = 77%
****

(5 2) /Log Book/NEGATIVE
*** Documents indexed by this node are:
1: S10 2: S15 3: S3 4: S9
*** This is 4 documents out of 26, = 15%
****

(6 1) /Preferred Teaching style/SURE
*** Documents indexed by this node are:
1: S1 2: S11 3: S12 4: S13
5: S14 6: S15 7: S16 8: S17
9: S18 10: S19 11: S20 12: S21
13: S22 14: S23 15: S24 16: S25
17: S26 18: S3 19: S5 20: S6
21: S7 22: S8 23: S9
*** This is 23 documents out of 26, = 88%
****

(6 2) /Preferred Teaching style/UNSURE
*** Documents indexed by this node are:
1: S10 2: S2
*** This is 2 documents out of 26, = 7.7%
****